B.M.S. COLLEGE OF ENGINEERING, BENGALURU – 19

(Autonomous Institute, Affiliated to VTU)

DEPARTMENT OF CHEMICAL ENGINEERING

M. TECH.
BIOCHEMICAL ENGINEERING
CHOICE BASED CREDIT SYDTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION
2018-2019

BMS COLLEGE OF ENGINEERING, BENGALURU – 19
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VISION OF THE DEPARTMENT

Be a globally recognized Chemical Engineering Department by imparting quality education

MISSION OF THE DEPARTMENT

High-quality education and experience to the budding Chemical Engineers

Chemical Engineering graduates to assume positions in process and other allied industries

Foster and encourage the pursuit of excellence in Chemical Science and Engineering

Inculcate global research potential

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

PEO1: Graduates pursue profession in chemical engineering and allied engineering

PEO2: Graduates work in diversified team

PEO3: Graduates will pursue higher education and research

GRAUDATE ATTRIBUTES FOR PG PROGRAM

(PROGRAM OBJECTIVES)

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The GAs of the PG program is the exemplars of the attributes expected of a graduate of an accredited program. The Graduate Attributes of the PG program of the NBA are

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: Ability to write and present a substantial technical report/document

PO3: An ability to demonstrate mastery in the Biochemical Engineering, at a level higher than the undergraduate program in Chemical and Biochemical engineering

BMS COLLEGE OF ENGINEERING, BENGALURU – 19
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1st Semester						Credit Based		
Course Code	**Course Title**	**Credits**			**Total**	**Marks**		
		L	**T**	**P**		**CIE**	**SEE**	**Total**
18CHBCBSMM	Mathematical Modeling in Biochemical Engineering	3	1	1	5	50	50	**100**
18CHBCPCBP	Bioprocess Engineering	3	1	1	5	50	50	**100**
18CHBCPCBR	Bioreactors	3	0	0	3	50	50	**100**
18CHBCPETP	Transport Phenomena in Bioprocess System	4	0	0	4	50	50	**100**
18CHBCPEBT	Biological Thermodynamics							
18CHBCPENA	Numerical Analysis							
18CHBCPEFE	Food Engineering	3	0	0	3	50	50	**100**
18CHBCPEBI	Bioinstrumentation							
18CHBCPEAP	Animal & Plant Cell Culture Techniques							
18ALLPICRM	Research Methodology & IPR	2	0	0	2	50	50	**100**
	TOTAL	18	2	2	22	300	300	**600**

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2nd Semester								Credit Based
Course Code	**Course Title**	**Credits**			**Total Credits**	**Marks**		
		L	**T**	**P**		**CIE**	**SEE**	**Total**
18CHBCPCPA	Process Automation	3	0	1	4	50	50	**100**
18CHBCPCRK	Reaction Kinetics	3	1	0	4	50	50	**100**
18CHBCPCBD	Bio-separation & Downstream Processing	3	0	1	4	50	50	**100**
18CHBCPEBW	Biological Waste Treatment & Engineering	3	0	0	3	50	50	**100**
18CHBCPEBM	Biomaterials & Tissue Engineering							
18CHBCPEMS	Membrane Separation Technology							
18CHBCPENB	Nanotechnology in Bioprocess Industries	3	0	0	3	50	50	**100**
18CHBCPEBS	Biosensors							
18CHBCPEPH	Pharmaceuticals							
18CHBCOEWE	Waste to Energy	4	0	0	4	50	50	**100**
18CHBCOEGT	Green Technology							
	TOTAL	19	1	2	22	300	300	**600**

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3rd Semester — Credit Based

Course Code	Course Title	Credits			Total Credits	Marks		
		L	T	P		CIE	SEE	Total
18CHBCPWP1	Project Work-Phase 1	0	0	16	16	50	50	**100**
18CHBCPESM	Safety Management in Bioprocess Industries	4	0	0	4	50	50	**100**
18CHBCPECM	Cost Management of Engineering Projects							
18CHBCPCSR	Seminar	0	0	2	2	50	50	**100**
18CHBCNCER	English For Research Paper Writing	Mandatory Course			0	50	-	-
18CHBCNCVE	Value Education							
TOTAL		4	0	18	22	200	150	**300**

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4th Semester									Credit Based
Course Code	**Course Title**	**Credits**			**Total Credits**	**Marks**			
		L	**T**	**P**		**CIE**	**SEE**	**Total**	
18CHBCPWP2	Project Work- Phase 2	-	-	12	12	50	50	**100**	
18CHBCPCIN	Internship	-	-	08	08	50	50	**100**	
18CHBCPEFT	Fermentation Technology	2	0	0	2	50	50	**100**	
18CHBCPEET	Enzyme Technology								
18CHBCNCDM	Disaster Management	Mandatory Course			0	50	-	-	
18CHBCNCPS	Pedagogy Studies								
18CHBCNCSY	Stress Management by Yoga								
TOTAL		2	0	20	22	200	150	**300**	

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I SEMESTER M TECH BIOCHEMICAL ENGINEERING
MATHEMATICAL MODELING IN BIOCHEMICAL ENGINEERING - 18CHBCPCMM

Subject Code	18CHBCBSMM	L-T-P	3-1-1
No of Lecture Hrs/Week	03+02 (Tutorials)	Exam hours	03
Total No. of Lecture Hours	39	Credits	05
CIE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Develop mathematical models for chemical and biochemical systems.

CO 2: Solve process models using different mathematical techniques.

CO 3: Analyze process models using advanced software tool

Unit 1	Hrs
Mathematical formulation of process: Applications of law of conservation of mass in mixing tank system, equilibrium still and single stage extraction. Heat transfer through multiwall cylinders and spheres, heat transfer in a jacketed vessel, Gas Compression system.	7
Unit 2	
Mathematical Modeling and Solution of Bioreactors: Operational stages in a Bioprocess industry, biochemical reactor, continuous stirred tank bioreactor-process description and mathematical modeling, fed-batch bioreactor- model development and mathematical solution.	9
Unit 3	
Mathematical Modeling and Solution of Bioprocess Equipment: Double Pipe Heat Exchanger, Shell & Tube Heat Exchanger, Design of single stage evaporation. Ideal isothermal batch, Plug flow and Mixed flow reactor.	7
Unit 4	
Modeling and Mathematical solution of complex process: Series and parallel homogeneous reaction. Stirred tank with coil heater, Series of stirred tank with coil heater, Pressure drop in pipe, Minimum fluidization velocity, Vapor–Liquid equilibria for binary mixtures, Calculation of bubble point dew point for ideal binary mixture.	9
Unit 5	
Laplace transformation and application: Laplace transformation, Laplace inverse transformation, Applications in Basic tank model – Level V/s time, Mixing tank, CSTR with first order reaction.	7

TEXT BOOKS

1. Jenson, V. G. and Jeffreys, F. V. **Mathematical methods in Chemical Engineering**, 2nd edition, Academic press, Elsevier, India, 2012.
2. Pradeep Ahuja, **Introduction to Numerical Methods in Chemical Engineering**, PHI Learning Pvt. Ltd, New Delhi, 2010.

REFERENCE BOOKS

1. Gaikwad, R.W, and Dhirendra, **Process Modelling and Simulation**, 2nd edition, Denetted & Co., 2006.
2. Grewal, B. S., **Higher Engineering Mathematics**, 40th edition, Khanna Publishers,

Delhi, India, 2009.

3. William. L Luyben, **Process Modeling Simulation and Control for Chemical Engineering,** 2nd edition, McGraw Hill, 1990
4. Jana, Aimya K., **Chemical Process Modelling and Computer Simulation**, 2nd edition, PHI Learning Private Limited, New Delhi, India, 2011.

Mathematical Modeling In Biochemical Engineering Laboratory

Minimum five experiments shall be conducted by students
Modeling and Mathematical Solution using MATLAB
List of experiments Laboratory Component:

1. Series and parallel reaction in batch reactor
2. Bubble point calculation
3. Dew point calculation
4. Continuous stirred tank bioreactor
5. Fed batch Bioreactor
6. Stirred tank with coil heater
7. Series of stirred tank with coil heater
8. Pressure drop in pipe
9. Minimum fluidization velocity
10. CSTR in series

I SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOPROCESS ENGINEERING - 18CHBCPCBP

Subject Code	18CHBCPCBP	L-T-P	3-1-1
No of Lecture Hrs/Week	03+02 (Tutorials)	Exam hours	03
Total No. of Lecture Hours	39	Credit	05
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES
CO1: Demonstrate the biological systems for engineering applications that requires skills from the various disciplines
CO2: Classify and identify the enzymatic processes and kinetics essential to work in the area of bioprocessing to arrive at a kinetic model to effectively represent the physical system
CO3: Establish the skills in investigations of the experimental data to nurture analytical and critical thinking abilities for data based decision making
CO4: Describe about various cultures, reactors, bioprocess applications and industrial processes

Unit 1	Hrs
Introduction: Bioprocess development- an interdisciplinary challenge, regulatory constraints for bioprocess engineering. Bioprocess engineering and technology. Classification of micro-organisms, Environmental and Industrial microbiology.	07
Unit 2	
Enzymes: Introduction, definition and enzyme classification, enzyme kinetics, various models, Experimentally determining rate parameters for MM Kinetics, effect of pH and temperatures, insoluble substrates, Numerical on enzymatic	09

Kinetics	
Unit 3	
Immobilised Enzyme Systems: methods and limitation of immobilization, Effects of diffusion and reaction on kinetics of immobilized enzymes, Effect of other environmental parameters like pH and temperature. Numerical on Immobilized enzymatic Kinetics	07
Unit 4	
Growth Kinetics Of Microorganisms: Growth Kinetics of Microorganisms, Quantification of growth kinetics, Filamentous cell growth model. Continuous culture: Optimum dilution rate in an ideal Chemostat. Introduction to fed-batch reactors. Immobilized Cells: Formulations, Characterization and Applications	09
Unit 5	
Mixed Cultures: Introduction to mixed cultures, Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model **Industrial Bioprocess:** Anaerobic process: Ethanol, lactic acid. Aerobic Process: Citric Acid, Penicillin.	07

TEXT BOOKS

1. Shuler M. L. and Kargi F, **Bioprocess Engineering**, 2nd edition, Prentice Hall, 2002
2. Pauline M. Doran, **Bioprocess Engineering,** 2nd edition, Academic Press, 2012

REFERENCE BOOKS

1. James E. Bailey and David F. Ollis, **Biochemical Engineering Fundamentals,** , 6th edition, Mc-Graw Hill International Edition, 6th edition, 2005.
2. James Lee, **Biochemical Engineering,** Prentice Hall, 1992.
3. Pelczar, **Microbiology Concept and Application**, 5th edition, McGraw Hill, 2001.

Bioprocess Engineering Laboratory

Minimum eight experiments shall be conducted.

List of experiments

1. Digestion of protein into amino acid
2. Cellulose degradation
3. Reducing sugar assay by Folin-Wu's method or DNS method
4. Hydrolysis –starch hydrolysis/ chitin hydrolysis using enzymes
5. Hydrolysis and substrate inhibition–starch hydrolysis/ chitin hydrolysis using enzymes
6. Enzyme purification by salt (ammonium phosphate) precipitation
7. Enzyme Immobilization by entrainment in alginate /gelatin gel
8. Aseptic culture techniques using steam autoclave
9. Aseptic culture techniques using petri dish preparation
10. Aseptic culture techniques using –Bugs are everywhere
11. Measurements of cell biomass concentration/cell count analysis
12. Sucrose assay by dinitro salicylic acid method / Folin-Wu's method
13. Cell fractionation based on density gradient

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I SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOREACTORS- 18CHBCPCBR

Subject Code	18CHBCPCBR	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	04
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO 1: Analyze and prepare a poster on the suitability of a bioreactor selecting from a wide choice of spectrum of bioreactors

CO 2: Apply the concept of transport processes in biological systems involving oxygen transfer, estimate the oxygen rates and coefficient with appropriate models

CO 3: Analyze the factors influencing the performance of bioreactors and apply judgment to select control systems to stabilize the parameters effecting the bioreactor performance

CO 4: Select the suitable modern tools to estimate the performance of the scaled up bioreactors and apply ethically a suitable sterilization process

Unit 1	Hrs
Introduction To Bioreactors: Overview of biological reactors: submerged liquid fermentation, solid state fermentation, Understanding of bioreactors: Definition of bioreactor, development of bioreactors, Purpose and importance of bioreactor, Classification of bioreactors, bioreactor for animal cell, plant cell cultivation/culture.	07
Unit 2	
Transport Phenomena In Bioprocess Systems: Gas liquid mass transfer in Cellular Systems. Determination of O_2 transfer rates. Mass transfer of freely rising or falling bodies. Forced Convection Mass Transfer: overall K_{La} Estimates and power requirements (review) for sparged and agitated vessels. Other factors affecting $K_{La,}$ Models, Power Consumption and Mass transfer for Non Newtonian fluids.	09
Unit 3	
Bioreactor Operations: Common operations of bioreactor, selection and identifications of factors for smooth operations of bioreactors; spectrum of basic bioreactor operations, bioreactor operations for immobilizes systems, plant and animal cell bioreactors operation.	09
Unit 4	
Controls In Bioreactors: Control task in bioreactor system, instrumentation in bioreactors, control variables and measurement devices, advanced control technique, consistency checks on measurement, adaptive online optimizations. Online and off line measurements and analytical methods.	07
Unit 5	
Sterilization And Scale Up Of Bioreactors: Sterilization of Reactors, Batch Sterilization, Continuous Sterilization, filter and air sterilization. Scale up problems in bioreactors, criteria of scale up, similarity criteria; scale up methods, generalized approaches to scale up.	07

TEXT BOOK

1. Tapabrata Panda, **Bioreactors Analysis and Design**, Tata McGraw Hill Education Pvt. Ltd, August, 2011.

2. James E.Bailey and David F. Ollis **Biochemical Engineering Fundamentals,** Mc-Graw Hill International Edition, 6th edition, 2005.

REFERENCE BOOKS

1. Michael L. Shuler and Fikret Kargi, **Bioprocess Engineering: Basic concepts**, 2nd edition, Prentice Hall, 2002.
2. Pauline M. Doran **Bioprocess Engineering** , 2nd edition, Academic Press, 2012.

I SEMESTER M TECH BIOCHEMICAL ENGINEERING

TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS- 16CHBCPETP

Subject Code	18CHBCPETP	L-T-P	4-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	52	Credits	04
CIE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Apply continuity equations of change for real problems involving basic mass transfer systems, and determination of oxygen utilization as well as transfer rates

CO 2: Adjudge applicability of mass transfer correlation to determine coefficients for Newtonian & Non-Newtonian fluids

CO 3: Apply Modeling to estimate the distribution of temperature in solids and fluids flowing in laminar regime

CO 4: Apply appropriate mathematical techniques to predict, estimate the concentration distribution in fluids in laminar regime and estimate transfer coefficient

Unit 1	Hrs
Analogies Between Momentum, Heat And Mass Transport: Momentum Energy and Mass Transport Newton's law of viscosity. Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction. Fick's law of diffusion. Effect of temperature and pressure on transport properties of fluids.	08
Unit 2	
Equations Of Change: Equation of continuity, Equation of motion; Navier – Stokes equation. Gas-Liquid Mass Transfer in Cellular System, Basic Mass- Transfer Concepts, Rates of Metabolic Oxygen Utilization, Determination of Oxygen Transfer Rates, Measurement of $k_l a$ Using Gas-Liquid Reactions, Mass-Transfer for Freely rising or Falling bodies, Mass-Transfer Coefficients for Bubbles and Bubbles Swarms, Estimation of Dispersed Phase Interfacial Area and Holdup, Holdup Correlations	14
Unit 3	
Forced Convection Mass Transfer: General Concepts Dimensionless Groups, Correlations for Mass-Transfer Coefficients and Interfacial Area, Example: Correlations for Maximum or Sauter Mean Bubbles or Droplet Diameters, Overall K_{LA} Estimates and Power Requirement for sparged and Agitated vessels, Mass Transfer Across Free Surfaces **Factors Effecting K_{LA}:** Estimation of diffusivities, Ionic Strength , Surface active agents, Non-Newtonian Fluids, Models and parameters for Non-Newtonian Fluids, Suspensions, Macromolecular Solutions, Power consumption and mass	14

Transfer in Non-Newtonian Fluids, Scaling of Mass Transfer equipment	
Unit 4	
Temperature Distribution In Solids And In Laminar Flow: Different situations of heat transfer: Heat conduction with internal generation by electrical, viscous energy sources. Forced and free convection heat transfer HEAT TRANSFER: Heat Transfer co-relations , Sterilization of gases and liquids by filtration	08
Unit 5	
Concentration Distributions In Laminar Flow: Steady state Shell mass balances. General Boundary conditions applicable to mass transport problems of chemical engineering. Diffusion through stagnant gas and liquid films. Equimolar counter diffusion.	08

TEXT BOOKS:

1. Bird, BR,, Stewart W.E. and Lightfoot, **E. N., Transport Phenomena**, John Wiley and Sons, Singapore, 2nd edition, 2009.
2. James E. Bailey and David F. Ollis, **Biochemical Engineering Fundamentals** by. Mc-Graw Hill International Edition, 6th edition, 2005.
3. Fruskey, Fan Yuan David F. Katz, **Transport Phenomena in Biological Systems,** 2nd edition, Pearson Prentice Hall Bioengineering, 2011.

REFERENCE BOOKS:

1. Welty, J.R., C.E. Wicks and R.E. Wilson, **Fundamental of Momentum, Heat and Mass Transfer**, John Wiley and Sons, 1976.
2. Sissom L.E. and D.R. Pitts, **Elements of Transport Phenomena**, McGraw Hill, New York, 1972.
3. Brodkey R.S. and H.C. Hershey, **Transport Phenomena**, McGraw Hill, 1988.

I SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOLOGICAL THERMODYNAMICS - 18CHBCPEBT

Subject Code	18CHBCPEBT	L-T-P	4-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	52	Credits	04
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Understand and apply the laws of thermodynamics to analyze energy flows in a biological system.
CO 2: Evaluate Gibbs free energy and calculate attainable work for engineering and biological system.
CO3: Study and present a results for Gibbs free energy and reaction kinetics

Unit 1	Hrs
Frontier Of Biological Thermodynamics: Energy conservation in living organism, Irreversibility and life, third law and biology, Entropy and protein stability, Energy, information processing and life, second law and evolution, Gibbs free energy, Equilibrium concepts for biological thermodynamics.	8
Unit 2	
Fundamental Concepts Of Thermodynamics: System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry.	8

Unit 3	
Entropy: Second law – Entropy and universe, Concept of heat engines, protein stability and calorimetric measurements. Fundamentals of Differential scanning calorimeter and Isothermal calorimeter in biological property measurements, Third law of thermodynamics, Maxwell equations, Gibbs-Duhem Equation and the Phase Rule, Legendre Transforms.	14
Unit 4	
Gibbs Free Energy And Its Applications: Gibbs free energy and equilibrium, Chemical potential, Ionic solutions, Equilibrium constant, Standard state in biochemistry, Acid and bases, Chemical coupling and redox reactions, Gibbs free energy in photosynthesis, Glycolysis citric acid cycle, Oxidative phosphorylation and ATP hydrolysis, Substrate cycling, Membrane transport, Enzyme substrate interaction, Haemoglobin, Protein solubility, stability and dynamics.	14
Unit 5	
Reaction Kinetics: Rate of a reaction, rate constant and order of the reaction, effect of temperature, collision and transition state theory, Electron transfer kinetics, Enzyme kinetics and inhibition, Reaction mechanism of lysozyme, protein folding and pathological misfolding, polymerisation, muscle contraction and the molecular motors.	08
TEXT BOOKS 1. Donald T. Haynie, **Biological Thermodynamics**, Cambridge press, 2008. 2. Robert A. Alberty, **Thermodynamics of Biochemical Reactions**, John Wiley publications, 2003..	
REFERENCE BOOKS 1. Smith J.M. and Van Ness H.C., **Introduction to Chemical Engineering Thermodynamic",** 5th edition, McGraw Hill, New York, 1996. 2. Narayanan, K.V., **Textbook of Chemical Engineering Thermodynamics** Prentice Hall of India Private Limited, New Delhi, 2001. 3. Rao Y.V.C., **Chemical Engineering Thermodynamics,** New Age International Publication, Nagpur, 2000.	

I SEMESTER M TECH BIOCHEMICAL ENGINEERING

NUMERICAL ANALYSIS – 18CHBCPENA

Subject Code	18CHBCPENA	L-T-P	4-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	52	Credits	04
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Develop ordinary and partial differential equations to solve chemical and biochemical engineering problems

CO 2: Apply appropriate numerical techniques to solve ODE and PDEs

CO 3: Analyze error in the solution opt using numerical techniques and minimize the error

CO4: Apply proper regression and curve fitting method to analyze experimental data.

Unit 1	Hrs
Error analysis: Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. **Regression and curve fitting:** Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines.	14
Unit 2	

Solution of algebraic equations: Solution of system of linear equations using Cramer's rule; Gauss Elimination; LU Decomposition; Iterative Methods. Solution of linear and nonlinear equation using Bisection, Secant, Newton-Raphson method.	14
Unit 3	
Numerical Differentiation and integration: Forward, Backward and central difference for first and second order derivative. Trapezoidal rules; Simpson's rules; Quadrature.	08
Unit 4	
ODEs: Initial Value Problems: Taylor series method, Euler's methods; Modified Euler's method, Runge-Kutta methods; Predictor-corrector methods.	08
Unit 5	
ODEs: Boundary Value Problems and PDE: Shooting method; Finite differences; Over/Under Relaxation (SOR). Solution of PDE; Solution of heat conduction equation, Solution of Laplace equation.	08

TEXT BOOKS

1. Kendall E. Atkinson, **An Introduction to Numerical Analysis**, Wiley India Private Limited, 2nd edition, 2008.
2. Pradeep Ahuja, **Introduction to Numerical Methods in Chemical Engineering**, PHI Learning Pvt Ltd, New Delhi, 2010.
3. Grewal, B. S., **Higher Engineering Mathematics**, 43rd edition, Khanna Publishers, India, 2014.

REFRENCE BOOKS

1. Gupta S.K. **Numerical Methods for Engineers**, New Age International, 1995.
2. Chapra S.C. and Canale R.P., **Numerical Methods for Engineers**, 5th edition, McGraw Hill, 2006.

I SEMESTER M TECH BIOCHEMICAL ENGINEERING
FOOD ENGINEERING - 18CHBCPEFE

Subject Code	18CHBCPEFE	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Comprehend the physical properties of food and its transportation
Identify the sources of contaminants, adulterants with its prevention for safe and healthy food
CO3: Identify different technologies involved in food processing and preservation and prepare document on technologies
CO 4: Select biocompatible packaging and additives for food products.

Unit 1	Hrs
Introduction to Food Engineering: Introduction, properties of food materials: Mechanical, thermal & Electrical properties of food, Rheological models, Water activity, Phase transition phenomena in foods, Properties of Liquids Handling Systems for Newtonian & Non-Newtonian Liquids, Transport of solid foods, Numericals on fluid flow in food processing.	07
Unit 2	
Food Processing and Preservation: Food deterioration – Causes. Aims and	09

objectives of preservation and processing. Processing systems: pasteurization and blanching systems, commercial sterilization systems, ultra-high pressure systems; pulsed electric field systems; alternative preservation systems. **Food Contamination and Adulteration:** Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. HACCP, FSSAI- The Food Safety and Standards Regulations- 2011.	
Unit 3	
High-Temperature Preservation: Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave & Ohmic heating. **Low-Temperature Preservation:** Principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidized bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation	09
Unit 4	
Food Additives: Introduction and need for food additives. Types of additives – antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety.	07
Unit 5	
Packaging Concepts: Introduction to packaging; food protection; product containment, commutation; convenience; mass transfer in packaging materials; permeability of packaging material to "fixed" gases; innovations in food packaging; passive packaging; active packaging; intelligent packaging; food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labeling.	07

TEXT BOOKS

1. Paul Singh and Dennis R. , **'Introduction to Food Engineering**', Elsevier Science and Technology, 5th edition, ISBN: 9780123985309, 2013.

REFERENCES

1. HoshaliS. Ramaswamy and Michele Marcotte, '**Food Processing: Principles and Applications'**, ISBN-13:978-1587160080, CRC Press.
2. ZekiBerk, '**Food Process Engineering and Technology'**, ISBN:978-0-12-373660-4, Elsevier Science and Technology,2009.
3. G. Subbulakshmi and Shobha A. Udupi, '**Food Processing and Preservation'**, New Age International, 2001.

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I SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOINSTRUMENTATION - 18CHBCPEBI

Subject Code	18CHBCPEBI	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Demonstrate an understanding of physics and engineering to explain the theoretical concepts governing the principle and functioning of the instrument

CO 2: Understand the design of the device, impact, complexity of each instrument, and its various models

CO 3: Analyze the data using theoretical knowledge from advance instruments for precise analysis

CO4: Demonstrate the applications and interpret the experimental data

Unit 1	Hrs
Basic laboratory Instruments: Principle and working of pH meter, Conductivity meter. **Spectroscopy:** UV Spectroscopy, Principles, Instrumentation and applications. Spectroflourimetry; Principle, Stoke's shift, quantum efficiency, instrumentation and applications, Numerical on Spectroscopy	06
Unit 2	
Electrophoresis: General principle, factors affecting electrophoresis, Gel electrophoresis: Types of gels: electrophoresis unit, preparation of gel, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing. **Microscopic identification of various microorganisms:** Phase contrast Microscopy, confocal microscopy, Scanning Ion Conductance Microscopy, Atomic force Microscopy and, Flow Cytometry.	09
Unit 3	
Chromatographic Techniques–I: Introduction to chromatography: General principles, column chromatography–columns, stationary phases. Packing of columns, Partition and adsorption chromatography. **Affinity Chromatography:** Principle, materials matrix, selection of attachment of ligands, practical procedures, specific and non-specific elution, applications. **Ion Exchange Chromatography:** Principle, types of exchangers, materials, choice of exchangers and buffers and applications. **Gel Filtration chromatography:** Principle, idea of distribution coefficient, exclusion limit, fractionation range, bed volume, void volume, elution volume, chemical properties of gel and applications. Numerical	09
Unit 4	
Chromatographic Techniques II: **Gas Chromatography:** Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. **High Performance Liquid Chromatography (HPLC):** Principle, components of HPLC system, column, column packing, chromatographic solvents, pumping systems, detectors systems and its applications. Numerical on Chromatography	08
Unit 5	
Atomic and Flame spectrophotometry: Principles, Instrumentation and	07

applications of flame emission / atomic absorption spectrophotometry and their comparative study. **Mass spectrometry:** Principles, Instrumentation and applications. Theory and applications of IR, NMR, Fluorescence, Atomic Absorption,	

TEXT BOOKS

1. Douglas A. Skoog, F. James Holler, Stanley R. Crouch., **Principles of Instrumental Analysis**, 6th Edition, Thomson Brooks/Cole, 2007.
2. Chatwal G R and Anand SK, **Instrumental Methods of Chemical Analysis**, 5th Edition, Himalaya Publishing House, New Delhi, 2014.

REFERENCE BOOKS

1. Lloyd R. Snyder, Joseph J. Kirkland, John W. Dolan., **Introduction to Modern Liquid Chromatography**, 3rd Edition, Wiley- Blackwell, Scholarly Publishing, 2016.
2. H.H. Willard, L.L. Merritt, J.N. Dean and F.A. Settle, **Instrumental methods of analysis**, I.B.H. Publishing House, New Delhi, 2016.

I SEMESTER M TECH BIOCHEMICAL ENGINEERING
ANIMAL & PLANT CELL CULTURE TECHNIQUES - 18CHBCPEAP

Subject Code	18CHBCPEAP	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Understand the characteristics of cells in scale up and large scale operation
CO2 : Prepare, sterilize and harvest culture media using advanced techniques
CO3 : Familiar with techniques for pharmaceutical and medical tissue products

Unit 1	Hrs
Essentials For Animal Cell Culture: History, scope, advantages & limitations. Planning, Construction, layout of laboratory. Essential equipment and culture Vessels (types & designs). Media and reagents: Physicochemical properties, Balanced salt solutions, complete media, Serum, serum free media, MEM, DMEM, RPMI and Ham's medium, role of antibiotics in media. Principles of sterile techniques.	09
Unit 2	
Animal Cell Culture Techniques: Establishment of primary cell cultures and cell lines, nomenclature, subculture, propagation and maintenance, suspension cultures & anchorage dependent cultures, Development and maintenance of Embryonic & adult stem cells, Organ and organotypic cultures, Contamination: Sources, types, Monitoring and Eradication, cryopreservation.	09
Unit 3	
Animal cell culture Techniques: Hybridoma technology; Genetic engineering in	07

animal cell culture, Operational strategies of mass cell culture. Cultured cells and evolution of cell lines; Maintenance of cultures – cell lines; Cloning of cell lines; Large scale cell cultures in biotechnology ; Somatic cell fusion	
Unit 4	
Plant Cell Culture: Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and Cell suspension culture system: methodology, kinetics of growth and, nutrient optimization	07
Unit 5	
Plant Cell Culture Techniques: Production of secondary metabolites by plant suspension cultures; Hairy root culture; transgenic plants; Plant products of industrial importance. Various techniques of plant cell cultures.	07

TEXT BOOKS

1. Freshney , **Culture of Animal Cells**, R I(2005), 5th edition, Wiley-Liss.
2. Spier RE and Griffiths J B , **Animal Cell Biotechnology** , Academic Press, 1988.
3. R.A. Dixon & Gonzales, **Plant Cell Culture: A Practical Approach**, IRL Press.

REFERENCE BOOKS

1. Introduction to cell & tissue culture by Jennie P. Mather & P.E.Robert.
2. Reinert J and Yeoman M M , **Plant Cell and Tissue Culture- A Laboratory manual**, Springer, 1994.
3. Nigel W. Scott, Mark R, Fowler, **Plant biotechnology the genetic manipulation of plants**, 2nd edition.

I SEMESTER M TECH BIOCHEMICAL ENGINEERING
INSTITUTE CORE
RESEARCH METHODOLOGY & IPR-18ALLPICRM

Subject Code	18ALLPICRM	L-T-P	2-0-0
No. of Lecture Hrs/Week	02	Exam hours	03
Total No. of Lecture Hours	26	Credits	02
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1 : Ability to write and present a substantial technical report/document
CO2 : Able to demonstrate a degree of mastery over the area of specialization

Unit 1	**Hrs.**
Meaning and sources of research problem, , Objectives and Characteristics of research – Errors in selecting research problem, Research methods Vs Methodology - Types of research-Criteria of good research – Developing a research plan.	6
Unit 2	
Investigations of a research problem - Selecting the problem - Necessity of defining the problem – Data collections-analysis- Importance of literature review in defining a problem - Survey of literature -Necessary instrumentations	5
Unit 3	
How to write paper-conference articles-poster preparation, thesis report writing, inclusion of references, journal reviewing process, journal selection process,	5

filling about journal template, developing effective research proposal-plagiarism-research ethics.	
Unit 4	
Nature of Intellectual property, IPRs- Invention and Creativity - Importance and Protection of Intellectual Property Rights (IPRs) – procedure for grant of patents and patenting under PCT-types of patents-technological research and innovation-international cooperation on IP.	5
Unit 5	
A brief summary of : Patents-Copyrights-Trademarks, patent rights-licensing and transfer of technology-patent databases-case studies on IPR-Geographical indications-new developments in IPR-protection of IPR rights	5
TEXT BOOKS 1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, **An introduction to Research Methodology**, RBSA Publishers, U.K., 2002. 2. Subbarau N R, **Handbook of Intellectual property law and practice,** S Viswanathan Printers and Publishing Private Limited, 1998.	
REFERENCE BOOKS 1. Kothari, C.R., **Research Methodology: Methods and Techniques**. New Age International. 418p, 1990. 2. Anderson, T. W., **An Introduction to Multivariate Statistical Analysis**, Wiley Eastern Pvt., Ltd., New Delhi. 3. Sinha, S.C. & Dhiman, A.K., **Research Methodology**, Ess Ess Publications. Vol. 1 and Vol. 2, 2002.	

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
PROCESS AUTOMATION- 18CHBCPCPA

Subject Code	18CHBCPCPA	L-T-P	3-0-1
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	04
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO 1: Analyze complex engineering problems and apply independent judgment for solving control problem involving open and close loops

CO 2: Evaluate the stability for open loop systems using modern tools and apply the same for the process of modeling.

CO 3: Use the modern tools and mathematical techniques in devising advanced control system and predict its performance..

CO 4: Analyze, experiment and interpret the stability of control systems by team.

Unit 1	Hrs
Review Of Systems: Review of first and higher order systems, closed and open loop response. Response to step, impulse and sinusoidal disturbances. Control valve types- linear, equal percentage and quick opening valves. Transient response. Block diagrams.	07
Unit 2	
Stability Analysis: Routh Hurwitz method, Root locus method, Frequency response, design of control system, controller tuning and process identification. Zigler-Nichols and Cohen-Coon tuning methods, Bode-Nyquist Plots-Process	09

modeling.	
Unit 3	
Special Control Techniques: Advanced control techniques, cascade, ratio, feed forward, adaptive control, selective controls, Smith predictor, internal model control, theoretical analysis of complex processes.	09
Unit 4	
Multivariable Control: Analysis of multivariable systems, Interaction, examples of storage tanks. Review of matrix algebra, Bristol arrays, Niederlinski index – Tuning of multivariable controllers.	07
Unit 5	
Sample Data Controllers: Basic review of Z transforms, Response of discrete systems to various inputs. Open and closed loop response to step, impulse and sinusoidal inputs, closed loop response of discrete systems.	07

Process Automation Laboratory

Note: Any five experiments

List of Experiments

1. Time constant of a Thermometer response
2. Second Order system U Tube Monometer
3. Single Tank – Step response
4. Interacting tanks- Step Response
5. Interacting tanks Pulse Response
6. Non-Interacting tanks- Step Response
7. Non-Interacting tanks- Pulse Response
8. P, PI and PID controller trainer
9. Valve characteristics

TEXT BOOKS

1. Coughnour D R, *"***Process system analysis and control***"*- 2nd edition, McGraw Hill, New York, 1991.
2. George Stephanopoules, *"***Chemical process control, An Introduction to Theory and Practical***"* - Prentice Hall, New Delhi, 1998.

REFERENCE BOOKS

1. Smith C A and Corripio A B *"***Principles and practice of automotive process control***",* John Wiley, New York, 1976.
2. Luyben *"***Process Modelling, Simulation and Control for chemical Engineers***",* 2nd Edn,, McGraw Hill, 1990.

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
REACTION KINETICS – 18CHBCPCRK

Subject Code	18CHBCPCRK	L-T-P	3-1-0
No of Lecture Hrs/Week	03+02 (Tutorials)	Exam hours	03
Total No. of Lecture Hours	39	Credits	04
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1: Develop kinetic equations of heterogeneous reaction for catalytic and non – catalytic reaction using various models with and without consideration of effective mass

and energy transport CO2: Conduct experiment and analyze the flow behavior, contacting, conversion and performance of non-ideal reactors using various models and comparison with ideal reactor CO3: Apply knowledge of reaction kinetics and flow behavior to design	
Unit 1	Hours
Kinetics Of Heterogeneous Reactions: Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Non catalytic fluid - solid reactions, Shrinking and unreacted core model.	07
Unit 2	
Population Balance Models: Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors.	09
Unit 3	
External Diffusion Effects In Heterogeneous Reactions: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.	09
Unit 4	
Internal Transport Processes In Porous Catalysts: Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.	07
Unit 5	
Design Of Heterogeneous Catalytic Reactors: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non-adiabatic fixed bed reactors. Two phase fluidized bed model, slurry reactor model and Trickle bed reactor model.	07
TEXT BOOKS 1. Fogler H.S, **Elements of Chemical Reaction Engineering**, Prentice Hall, 1991. 2. John Villadsen, Jens Nielsen, Gunnar Lidén, **Bioreaction Engineering Principles**, Springer Science & Business Media, 2011. 3. Bischoff and Froment, **Chemical Reactor Design and Analysis**, Addision Wesley, 1982.	
REFERENCE BOOKS 1. Levenspiel, O., **Chemical Reaction Engineering** , 3rd edition, 2005. 2. Smith J.M, **Chemical Engineering Kinetics**, 3rd edition, McGraw-Hill, 1984.	

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOSEPARATION & DOWNSTREAM PROCESSING- 18CHBCPCBD

Subject Code	18CHBCPCBD	L-T-P	3-0-1
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	04
CIE	50 Marks	SEE	50 Marks
COURSE OUTCOMES CO1: Apprehend the various downstream processes and select an unit operation to purify the product suitable for a particular biological mixture CO2: Assess the purity of the desired product using modern tools by selecting an			

appropriate separation process considering the economics and process feasibility CO3: Use of membrane diffusion as a tool for separation with clear knowledge of applicability and limitations CO4: Design a suitable polishing and packaging operation with focus on the market, economics and shelf life of the product	
Unit 1	Hrs
Introduction: Role and importance of downstream processing in biotechnological processes. Problems and requirements of byproduct purification. Economics of downstream processing in Biotechnology. Cost cutting strategies, Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes	07
Unit 2	
Primary Separation Techniques: Cell disruption methods for intracellular products, removal of insolubles, biomass and particulate debris. Separation techniques; flocculation and sedimentation, Centrifugation (ultra and differential) and filtration methods. Solid-liquid separation with theory of batch filtration, Theories of Centrifugal force, equipment and centrifugal filtrations	07
Unit 3	
Isolation And Product Purification: Extraction: Principles of extraction, batch and staged extraction, differential extraction. Adsorption: Chemistry of adsorption, batch and continuous adsorption. Precipitation: Precipitation methods with salts, organic solvents, and polymers.	09
Unit 4	
Membrane Separation Processes: Membrane based separations theory; Design and configuration of membrane separation equipment; Applications: Use of membrane diffusion as a tool for separating and characterizing naturally occurring polymers; enzyme processing using ultra filtration membranes; separation by solvent membranes; reverse osmosis.	09
Unit 5	
Finishing Operations And Formulations: Finishing operations: crystallization: Basic concepts, crystal size distributions, batch and recrystallization. Drying: basic concepts, and equipment, lyophilization: Principle of lyophilization, working and applications and formulations	07

TEXT BOOKS

1. Belter PA, Cussler E and Wei Shan Hu, **Bioseparation –Downstream Processing for Biotechnology**, John Wiley & Sons, New York, 1988.
2. Roger G Harrison, **Bioseparataions**, Science and Engineering, Oxford Publications, 2006.

REFERENCE BOOKS

1. Neeraj Mishra, Akhilesh Dubey, **Bioseparation Technology**, CRC Press, 2012
2. Elliott Goldberg, **Handbook of Downstream Processing**, Blackie Academic and Professional, 1997.
3. Verrall, M.S. **Downstream Processing of Natural Products: A practical handbook,** John Wiley & Sons Ltd., England, UK, 1996.
4. Mulder, M. **Basic Principles of Membrane Technology**: Kluwer Academic Publishers, Netherlands, 1996.
5. **Product Recovery in Bioprocess Technology,** BIOTOL Series, VCH,1990

6. Asenjo J and Dekker M, **Separation Process in Biotechnology**, Marcell Dekker Publications,1993.

BIOSEPARATION & DOWNSTREAM PROCESSING LABORATORY

Minimum eight experiments shall be conducted. At least three from each part shall be conducted.

List of Experiments

Part A

1. Isothermal continuous plug flow reactor
2. Semi batch reactor
3. Continuous stirred tank reactor
4. Effect of temperature on rate of reaction
5. Effect of Temperature on enzyme activity
6. RTD studies in tubular reactor
7. RTD studies in tank reactor

Part B

1. Aqueous two phase extraction
2. Ammonium sulphate precipitation of proteins
3. Leaf filter
4. Plate and frame filtration Coagulation Jar Test

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOLOGICAL WASTE TREATMENT & ENGINEERING – 18CHBCPEBW

Subject Code	18CHBCPEBW	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO: Explain the different regulatory standards with design criteria for environmental parameters

CO2: Demonstrate the wastewater treatment criteria based on the regional requirement

CO3: Comprehend the reaction kinetics, reactor selection and its process analysis

CO4: Design the treatment plant based on the fundamentals studies, bench scale and pilot plant studies

Unit 1	Hrs
Introduction: Objectives of wastewater treatment. Flow measurements and Composition. Characterization -Properties and analysis of wastewater, Problems on wastewater characterizations. Waste-water treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central	07
Unit 2	
Physical and Chemical treatment of wastewater: Screens, Comminutes, Grit chambers, Flow equalizations, Sedimentation, Flotation, Granular medium filtration. Chemical treatment: chemical precipitation, Adsorption, Disinfection with chlorine, ozone, Ultraviolet light etc. Treatment disposal of sludge – Sludge characteristics, concentration. Aerobic/Anaerobic sludge digestion, sludge	09

conditioning, Dewatering and drying. Incineration and wet oxidation.	
Unit 3	
Microbiology of waste treatment – Growth and inhibition of bacteria. Kinetic of Biological growth, Batch culture substrate limited growth, Cell growth and substrate utilization, Effects of endogenous metabolism. Monod's and Michael's Menton kinetics and their applications. Determination of kinetic coefficients. Fundamentals of process analysis, Mass balance analysis, Reactors and their hydraulic characteristics, Reaction kinetics and Reactor selection. (Batch, Plug flow, Completely stirred tank reactor and packed and fluidized bed reactor).	09
Unit 4	
Biological Treatment Processes: Aerobic/Anaerobic attached and suspended growth treatment processes- Activated sludge process: Process analysis: Completely mix with recycle, Sequential Batch Reactor (SBR), Rotating biological contactor/disc (RBC), Trickling filter, UASB digester, aerated lagoon, stabilization ponds.– Standard type and modifications. Aerators/diffusers. With applicable numerical	07
Unit 5	
Biological Nutrient Removal: Nitrogen removal with and without phosphorous removal, Nitrogen and Phosphorous removal, Phosphorous removal with or without nitrifications, Removal of ammonia by biological nitrifications, Removal of Nitrogen by biological nitrification/denitrifications. Combined removal of Nitrogen and Phosphorus by Biological, Physical and Chemical methods.	07

TEXT BOOKS

1. Eckenfelder and O'Conner, **Biological Waste Treatment**, 2001.
2. Metcalf and Eddy, **Wastewater Engineering Treatment**, Disposal & Reuse, Tata McGraw Hill, 1991.

REFERENCE BOOKS

1. H.E. Babbilt and R.Baumann, **Sewage and Sewage Treatment**, 1986.
2. Webber W J, **Physicochemical processes for water quality.**
3. Fasir G M , Geyer JG and Okun, **Waste water engineering.**
4. Ronand Droste, **Theory and practice of water and wastewater treatment**, John Wiley and sons, Canada, 2005.
5. George Tchobanoglous and Franlin L. Burton, ***Wastewater Engineering Treatment, Disposal and Reuse***, Tata McGraw Hill Publishing Co. Ltd, 1990.

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOMATERIALS & TISSUE ENGINEERING- 18CHBCPEBM

Subject Code	18CHBCPEBM	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO 1: Demonstrate the concepts of biocompatibility and other properties of biomaterials

CO 2: Classify and characterize biomaterials
CO 3: Understand the synthesis and properties of biopolymers in use as biomaterials
CO 4: Demonstrate tissue engineering and applications

Unit 1	Hrs
Introduction: Overview of Biomaterials, Impact of Biomaterials, Safety and efficacy Testing, Legal issues related to development of biomaterials, Biocompatibility. Structure and properties of materials, Mechanical Properties of materials, thermal treatments	07
Unit 2	
Interactions Of Materials And Its Characterization: Interactions of materials with human body, bio-compatibility of materials, metals, alloys, ceramics, polymers and composites as biomaterials.	07
Unit 3	
Biopolymers: Biopolymers, Collagen, Elastin, Silk, Chitosan, Cellulose, And Alginate, material for drug delivery: biodegradable polymers. Applications of Biomaterial. **Hydrogels:** Synthesis and Properties of Hydrogels, Applications of Hydrogels	09
Unit 4	
Applications Of Biomaterials: Orthopedic implants, Dental implants, Ophthalmology Cardiovascular implants. Materials for artificial organs transplant and Extracorporeal device. Recent developments in biomaterials, Role of Nano-biomaterials and its various application	09
Unit 5	
Tissue Engineering: Introduction, Tissue Engineering of Skin Dermal and facial prosthesis, Bone, tendon, Adipose, FDA Regulation, Regulation of Pharmaceutical/ Medical Human Tissue Products in Europe/USA, Other considerations Relevant to Engineered Tissues.	07

TEXT BOOKS

1. Sujatha V. Bhat, **Biomaterials**, 2nd edition, Narosa Publishing House, Mumbai, 2010
2. Joon Park, R. S. Lakes, ***Biomaterials: An Introduction***, 3rd edition, Springer Press, 2009 (ISBN-13: 978-1441922816)
3. John P. Fisher, A G Mikos & Joseph D. Bronzino, **Tissue Engineering**, CRC Press, 2007

REFERENCE BOOKS

1. Buddy D. Ratner, **Biomaterials Science: An Introduction to Materials in Medicine,** 2nd edition, Academic Press, 2004.
2. H. Reza Rezaie, L. Bakhtiari, A. Öchsner, **Biomaterials and their Applications,** Springer Publications, 2015.
3. C. Mauli Agrawal, Joo L. Ong, **Introduction to Biomaterials: Basic Theory with Engineering Applications**, Cambridge Texts in Biomedical Engineering, Cambridge University Press, (ISBN-13: 978-0521116909) 2016.
4. Anthony Atala & P Lanza, **Methods of Tissue Engineering** , Academic Press Elsevier, 2006.

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II SEMESTER M TECH BIOCHEMICAL ENGINEERING
MEMBRANE SEPARATION TECHNOLOGY- 18CHBCPEMS

Subject Code	18CHBCPEMS	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO 1: Classify and characterizer the membranes for bio separation.
CO 2: Understand the preparation of membranes
CO 3: Analyze and select the appropriate method of membrane and membrane process.
CO 4: Evaluate the flux of solvent and solute through membrane.

Unit 1	Hrs
Introduction: Membrane separation process, Definition of Membrane, Membrane types, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials and properties. Membrane Units	07
Unit 2	
Characterization Of Membranes: Preparation of synthetic membranes: Phase inversion membranes, Preparation techniques for immersion precipitation, Synthesis of asymmetric and composite membranes and Synthesis of inorganic membranes.	09
Unit 3	
Transport In Membranes: Introduction, Driving forces, Non-equilibrium thermodynamics, Transport through porous membranes, transport through non-porous membranes, Transport through ion-exchange membranes. Pressure driven membrane processes, Concentration as driving force, Electrically driven membrane processes	07
Unit 4	
Membrane Processes: Reverse osmosis, electro dialysis, gas permeation; pervaporation, concentration, pressure, electrically and thermally driven membrane processes; membrane bioreactors, Liquid Membranes **Major Areas Of Applications:** Chemical industry, pharmaceutical industry, Food Industry, and Biotechnology industries	09
Unit 5	
Limitations Of Membranes: Polarization Phenomena And Fouling: Concentration Polarization, Pressure Drop, Membrane Fouling, And Methods To Reduce Fouling. Factors Affecting Retentivity, Concentration Polarization, Gel Polarization, Fouling, Cleaning And Regeneration Of Membranes.	07

TEXT BOOK

1. Nath K., **Membrane Separation Processes**, Prentice-Hall Publications, New Delhi, 2008.

REFERENCE BOOKS

1. Marcel Mulder, **Basic principles of Membrane Technology**, Kluwer Academic Publishers, London.
2. W S Ho, K K Sirkar, **Membrane Handbook** , Kluwer.
3. Baker R. W., **Membrane Technology and Research**, Inc.(MTR), Newark, California, USA, 2004.
4. J.D. Seader, Ernest J. Henley, D. Keith Roper, *"**Separation Process Principles:Chemical and Biochemical Operations**"*, 3rd edition, Wiley 2010.

5. Geankoplis C. J., "**Transport Processes And Separation Process Principles**" 4th edition, Prentice-Hall of India Private Ltd. , New Delhi.

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
NANOTECHNOLOGY IN BIOPROCESS INDUSTRIES – 18CHBCPENB

Subject Code	18CHBCPENB	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1: Demonstrate the knowledge in the interface between chemistry, physics and biology on the nano structural level with a focus on bioprocess industries use
CO2: Diagnose the concepts of BioMEMS and their use in drug delivery
CO3: Demonstrate the available nanomaterials in biological system
CO4: Imply the significance of applications for economical use of nanomaterials

Unit 1	Hrs
Methods Of Measuring Properties: Atomic size, crystallography, Particle size determination, Surface structure, Microscopy- Transmission Electron Microscopy, Field Ion Microscopy, Scanning Microscopy; Spectroscopy- Infrared & Raman Spectroscopy, Photoemission and X-ray Spectroscopy, Magnetic resonance.	07
Unit 2	
Properties Of Individual Nanoparticles: Metal nanoclusters, Semiconducting nanoparticles, Rare gas and molecular clusters, methods of synthesis- RF Plasma, Chemical Methods, Thermolysis, Pulsed Laser methods. Carbon nanostructures: Carbon molécule, Clusters, Carbon nanotubes, Applications. Bulk nanostructured materials: Solid disordered nanostructures, nanostructure crystals	07
Unit 3	
Nanostructured Ferromagnetism: Basics of ferromagnetism, Effect of bulk Nano structuring of magnetic properties, dynamics of nano magnets. Nano structures in zeolite cage. Quantum wells, wires and dots: Preparation of quantum nanostructures, Single electron tunneling, Applications. Catalysis: Nature of catalysis, Surface area of nanoparticles, porous materials, Pillered clays, Colloids.	09
Unit 4	
BioMEMS: Introduction and Overview, BioMEMS Applications: Case Studies in Bio-magnetic Sensors, Applications of optical and chemical transducers. Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS. Drug Delivery using Nano biosensors, Drug Delivery Applications, Bioavailability, Sustained and targeted release, Drug Delivery, Health Risks, and Challenges**.**	09
Unit 5	
Biological Nanomaterials: Biological building blocks, biological nanostructures. Nanomachines and nanodevices: Microelectromechanical systems (MEMSs), Nanoelectromechanical Systems (NEMSs) - Fabrication, Devices. Molecular and Supramolecular Switches. Nano diagnostics: Diagnostics and Sensors, Rapid *Ex-Vivo* Diagnostics, Nano sensors as Diagnostics, Nanotherapeutics. Nanofabricated devices to separate and interrogate DNA, Interrogation of immune and neuronal cell activities	07

through micro- and nanotechnology based tools and devices.	

TEXT BOOKS

1. Charles P. Poole, Jr., Frank J. Owens, **Introduction to Nanotechnology**, John Wiley and Sons, 2009.
2. Hari Singh Nalwa (Editor), **Handbook of Nanostructured Materials and Nanotechnology**, Vol. 1-5, Academic Press, Boston, 2000.

REFERENCE BOOKS

1. CNR Rao, **Nanoworld- An Introduction to Science and Technology**, JNCASR, Bengaluru, 2010

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
BIOSENSORS - 18CHBCPEBS

Subject Code	18CHBCPEBS	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1. Acquaint with the need of biosensors, types of sensors and their parameters
CO2. Understand the role of transducers in chemical analytics while working with biosensors.
CO3. Demonstrate the kinetic modeling of biosensors and biosensors applications in industrial online monitoring

Unit 1	Hours
Introduction: A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors	07
Unit 2	
Types Of Biosensors: Biocatalysts based biosensors, bio affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions	07
Unit 3	
Transducers In Biosensors: Various types of transducers; principles and applications; Bio-, chemi-, and electrochemiluminescence for fiber-optic biosensors; Fluorescence-based fiber-optic biosensors	09
Unit 4	
Kinetic Modeling For Biosensors: The purpose and practice of modeling; The flux equations, The flux diagram for the membrane/enzyme/electrode, Deriving a complete kinetic model; Kinetic modeling in other types of biosensors- Potentiometric enzyme electrodes, Optical and photometric biosensors, Immunosensors	09
Unit 5	
Application And Uses Of Biosensors: Biosensors in medicine and health care, biosensors for agriculture and food; Low cost- biosensor for industrial processes for online monitoring; biosensors for environmental monitoring.	07

TEXT BOOKS

1. Rajmohan Joshi, **Biosensors,** 1st edition, Gyan Books, 2006.
2. Cooper J.M. and Anthony E.G, **Biosensors,** 2nd edition, Oxford University Press, 2004.

3. Turner A.P.F, Karube.I and Wilson,G.S, **Biosensors Fundamentals and applications**, Oxford University Press, 1990.
4. Sadana.A, **Biosensors: Kinetics of Binding and Dissociation Using Fractals,** 1st edition, Elsevier B.V, 1995

REFERENCE BOOKS

1. Ashok M and Kim Rogers, **Enzyme & Microbial Biosensors: Techniques and Protocols (Methods in Biotechnology),** 1st edition, Humana Press, 1998.
2. Ashok M and Kim Rogers, **Affinity Biosensors: Techniques and Protocols (Methods in Biotechnology)**, 1st edition, Humana Press, 1998.
3. Damia Barcelo, **Biosensors for the Environmental Monitoring of Aquatic Systems: Bioanalytical and Chemical Methods for Endocrine Disruptors**, 1st edition, Springer, 2009.

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
PHARMACEUTICALS- 18CHBCPEPH

Subject Code	18CHBCPEPH	L-T-P	3-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	03
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1: Emphasize the knowledge on biopharmaceuticals and to identify the pharmaceuticals of plant, animal and microbial origin
CO2: Analyze the sources of biopharmaceuticals and to identify various applications.
CO3: Design the biopharmaceutical manufacturing process and study the products using appropriate characterization technique
CO4: Design a suitable drug delivery process, inculcate critical thinking to perform clinical trials and to design advanced drug delivery systems

Unit 1	Hrs
Biopharmaceuticals an Overview History of biopharmaceutical industry, Birth and age of biopharmaceuticals, Biopharmaceuticals: current status and future prospects, Distinctions between Chemical Drugs Versus Biopharmaceuticals ,Traditional pharmaceuticals of biological origin, Pharmaceuticals of animal, plant and microbial origin	07
Unit 2	
Sources of Biopharmaceuticals: ***E. coli*** as a source of recombinant, therapeutic proteins, Expression of recombinant proteins in animal cell culture systems, Additional production systems: yeasts, Fungal production systems, Transgenic animals, Transgenic plants, Insect cell-based systems **Products of Biopharmaceuticals:** Cytokines, enzymes, hormones, clotting factors, vaccines, monoclonal antibodies, cell therapies, antisense drugs, and peptide therapeutics.	07
Unit 3	
Biopharmaceutical Manufacturing: Clean rooms, Water for biopharmaceutical processing, Generation of purified water and water for injections (WFI), Documentation and Specifications, Manufacturing formulae, processing and packaging instructions, Generation of manufacturing records **Production and Analysis of Final Product**: Cell banking systems, Upstream	09

processing, Microbial cell fermentation, Mammalian cell culture systems, Downstream processing, Final product formulation. Product potency, Determination of protein concentration, Detection of protein-based product impurities, Capillary electrophoresis, High-pressure liquid chromatography (HPLC), Mass spectrometry, Immunological approaches to detection of contaminants.	
Unit 4	
Delivery of Biopharmaceuticals: Oral delivery systems, Pulmonary delivery, Nasal, Transmucosal and transdermal delivery systems. **Clinical Trials**: Pharmacokinetics and pharmacodynamics, Toxicity studies, Reproductive toxicity, teratogenicity, Mutagenicity, carcinogenicity and other tests, Clinical trial design, Trial size and study population, the role and remit of regulatory authorities for The Food and Drug Administration and new drug application	09
Unit 5	
Advanced Drug Delivery and design: Introduction, Drug Therapeutic Index and Clinical Impact, Routes of Therapeutic Protein Administration, Approaches Using Devices, Physiological and Mechanistic Approaches, Molecular Approaches to design - Computer-Aided Drug Design, ligand structure based drug design, Quantitative Structure Activity Relationship (QSAR)	07

TEXT BOOKS

1. Gary Walsh, **Biopharmaceuticals Biochemistry and Biotechnology**, 2nd edition, John Wiley & Sons, Ltd, 2003.
2. Susanna Wu-Pong ,Yon Rojanasakul, **Biopharmaceutical Drug Design and Development**, Humana Press, 2008

REFERENCE BOOKS

1. Gary Walsh and Brendan Murphy, **Biopharmaceuticals, An Industrial Perspective**, Kluwer Academic Publishers, 1999.
2. Shargel, L. and Yu, A.B.C., **Applied Bio pharmaceutics and Pharmacokinetics**, McGrawHill, New York, 5th ed., 2005.
3. Jörg Knäblein, **Modern Biopharmaceuticals, Recent success stories**, (Editor), Wiley-VCH Verlag GmbH & Co, Weinheim, Germany, 2013.
4. Gary Walsh, **Pharmaceutical Biotechnology Concepts and Applications**, John Wiley & Sons Ltd, 2007.
5. O. Kayser and R.H. Muller, **Pharmaceutical Biotechnology, Drug Discovery and Clinical Applications**, Wiley-VCH Verlag GmbH & Co. 2004.

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
WASTE TO ENERGY – 18CHBCOEWE

Subject Code	18CHBCOEWE	L-T-P	4-0-0
No of Lecture Hrs/Week	03	Exam hours	03
Total No. of Lecture Hours	39	Credits	04
CIE Marks	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Establish the sources and composition of biomass and biomass characterization
CO2:Demonstrate production technologies, applications and also characterize the bioethanol and biodiesel
CO3:Demonstrate the biogas production technique and the design criteria of equipment
CO4: Determine the biomass processing techniques for the improvement of quality of

biofuels	
Unit 1	Hrs
Bioenergy Resources: Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels, Structural properties, Physical properties, properties of microbial biomass, Biomass resource assessment. Energy plantations - Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell.	09
Unit 2	
Ethanol: Biomass constituent to liquid fuels, Liquid fuel alcohol from sugar cane molasses, Sweet sorghum, and other sources like corn and lignocelluloses. Lignocelluloses ethanol production technologies, conversion. Corn ethanol production technologies, Chemistry of ethanol fermentation, Byproducts from fermentation process.	07
Unit 3	
Biodiesel: Definition and properties of biodiesel: Properties of Biodiesel, Catalyst used for biodiesel production. Biofuels from vegetable oil: Production of vegetable oil, Composition, Process of extraction of vegetable oil, Applications. Trans-Esterification of Oils to produce bio-diesel. Biofuels from algae: Microalgae growth, algae harvesting, Extraction and utilization of liquid biofuels.	09
Unit 4	
Biogas Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, Animal residues: Microbial and biochemical aspects-Operating parameters for biogas production Kinetics and mechanism - Dry and wet fermentation. Digesters for rural application-High rate digesters for industrial waste water treatment.	07
Unit 5	
Pyrolysis And Gasification Of Biomass: Biomass conversion routes, Biomass densification technologies, Biomass combustion of woody biomass. Biomass pyrolysis, cogeneration in biomass Processing Industries. Guidelines for designing downdraft gasifiers. Pyrolysis of biomass-Pyrolysis regime, Effect of particle size, Temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, Temperature and of introducing steam and oxygen. Design and operation of fixed and fluidized bed gasifiers.	07

TEXT BOOKS

1. Sunggyu Lee and Y T Shah**,** ***Biofuels and Bioenergy- Process and Technology,*** CRC Press, 2014.
2. VVN Kishore**,** ***Renewable energy engineering and technology –principles and practice,*** TERI Press, New Delhi, 2010.

REFERENCE BOOKS
1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, **Biofuels Engineering Process Technology** , Mc Graw Hill Publishers, New York, 2008
2. Jonathan R.M, **Biofuels – Methods and Protocols (Methods in Molecular Biology Series),** Humana Press, New York, 2009.
3. Lisbeth Olsson (Ed.), **Biofuels (Advances in Biochemical Engineering/Biotechnology Series**, Springer Verlag Publishers, Berlin, 2007.
4. G D Rai, **Nonconventional Energy Source***s*, Khanna publications, 4th edition, 2010

II SEMESTER M TECH BIOCHEMICAL ENGINEERING
GREEN TECHNOLOGY-18CHBCOEGT

Subject Code	18CHBCOEGT	L-T-P	4-0-0
No of Lecture Hrs/Week	04	Exam hours	03
Total No. of Lecture Hours	26	Credits	04
CIE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Demonstrate the tools of green technology and zero waste systems

CO 2: Apply the basic principles of green chemistry and atoms

CO 3: Demonstrate the life cycle assessment methods and tools

CO4: Develop methods of pollution prevention and to predict a better design for environment

Unit 1	Hrs
Introduction: Green chemistry and technology for sustainable development, Environmental laws, carbon credits, environmental management systems standards-ISO 14000 series	04
Unit 2	
green chemistry: Principles of green chemistry, atom efficiency, energy conservation, waste minimization, substitution	07
Unit 3	
Life Cycle Assessment: History, Process, Methodology, Streamlining, and application	07
Unit 4	
Pollution Prevention Planning: Structure of the pollution prevention process, environmental audits	04
Unit 5	
Designs And Case Studies: Design for the environment and improvement in manufacturing operations, Case studies	04

TEXT BOOKS
1. Anastas P T , Warner J C , "**Green chemistry: Theory and Practice**", Oxford Science Publications, Oxford, 1998
2. Paul L Bishop, "**Pollution prevention: Fundamentals & Practice**", McGraw Hill, 2000.

REFERENCE BOOKS
1. Mike Lancaster, "**Green Chemistry-An Introductory text**", Royal Society of

Chemistry, 2010.
2. Boyle, Godfrey, Bob Everett, Janet Ramage, "**Energy Systems and Sustainability: Power for a Sustainable Future"**, Oxford University Press, 2004.

III SEMESTER M TECH BIOCHEMICAL ENGINEERING
PROJECT WORK PHASE 1 - 18CHBCPWP1

Subject Code	18CHBCPWP1	Project Work Phase-1	0-0-16
No of Lecture Hrs/Week	---	Exam hours	03
Total No. of Lecture Hours	---	Credits	16
CIE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Select and define an appropriate research problem and parameters through literature review
CO2: Prepare a project review and also write protocols to perform the experiments in an organized manner
CO3: Conduct the research and present the work progress through seminars
CO4: Write a research proposal for the grant and carry out data analysis
CO5: Write precise project report with appropriate references

Each student will be assigned an experimental, design, a case study or an analytical problem, to be carried out under the supervision of an internal guide. It should be relevant to the field and preferably of current research. The project work should be assigned at the beginning of the third semester. Minimum of two of research publications /patents data shall be reproduced through experimentation. The project work should be completed at the end of the fourth semester. The project work shall be evaluated as an external examination by the committee constituted by the HOD.

III SEMESTER M TECH BIOCHEMICAL ENGINEERING
SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES-18CHBCPESM

Subject Code	18CHBCPESM	L-T-P	4-0-0
No of Lecture Hrs/Week	02	Exam hours	03
Total No. of Lecture Hours	52	Credits	04
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1: Understand the biohazard and its abatement in a safe way
CO2: Demonstrate the risk analysis, assessment and abatement of hazards for the safe operation of processes in biochemical industries
CO3: Apprehend process safety in Biotechnological based products in order to comply with industrial & regulatory standards

Unit 1	Hrs
Biotechnology And Society : Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology,	08

issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability; Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.	
Unit 2	
Bio-Safety Concepts And Issues : Rational versus subjective perceptions of risks & benefits, relationship between risk, hazard, exposure & safeguards, biotechnology & biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety	14
Unit 3	
Biosafety management: Key to the environmentally responsible use of biotechnology; Ethical implications of biotechnological products and techniques; Social & ethical implications of biological weapons	14
Unit 4	
Regulations: Good manufacturing practice & Good lab practices (GMP & GLP). GMOs: Concerns & Challenges, Regulatory mechanism for GMO, Case studies in IPR (Turmeric & Neem Patent Case) and Biosafety (Bt Bringal and Bt cotton, Golden Rice)	08
Unit 5	
Food Safety: The GM-food debate and biosafety assessment procedures for biotech foods & related products, case studies of relevance. Environmental aspects of biotech applications	08

TEXT BOOKS

1. Deepa Goel & Shomini Prasar, **IPR, Biosafety, and Bioethics**, Pearson Press, New Delhi 2013
2. Thomas JA and Fuch RI, **Biotechnology and safety assessment**, Academic press 2002.

REFERENCE BOOKS

1. Fleming DA and Hunt DL., **Biological Safety principles and practices**, ASM Press, 2000.
2. Lees F.P, **Loss Prevention in Process Industries**, 2nd edition, Butterworth Heinemann, 1996
3. Patterson D, **Techniques of safety managements**, McGraw Hill, 1978
4. Handley W., **Industrial Safety hand book**, 2nd edition, McGraw Hill, 1977
5. Levine S.P and Martin, **Protecting personnel at hazardous waste sites**, Butterworth, 1985.

III SEMESTER M TECH BIOCHEMICAL ENGINEERING
COST MANAGEMENT OF ENGINEERING PROJECTS - 18CHBCPECM

Subject Code	18CHBCPECM	L-T-P	4-0-0
No of Lecture Hrs/Week	02	Exam hours	03
Total No. of Lecture Hours	52	Credits	04
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES

CO1: Perform and evaluate present worth, future worth and annual worth analyses on one

of more economic alternatives
CO2: Perform and evaluate payback period and capitalized cost on one or more economic alternatives
CO3: Carry out and evaluate benefit/cost, life cycle and breakeven analyses on one or more economic alternatives

Unit 1	Hours
Introduction and Overview of the Strategic Cost Management Process: Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.	08
Unit 2	
Project: meaning, Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution, Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process	14
Unit 3	
Cost Behavior and Profit Planning: Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement	14
Unit 4	
Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.	08
Unit 5	
Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	08

TEXT BOOKS

1. Rajmohan Joshi, **Biosensors,** 1st edition, Gyan Books, 2006.
2. Cooper J.M. and Anthony E.G, **Biosensors,** 2nd edition, Oxford University Press, 2004
3. Turner A.P.F, Karube.I and Wilson,G.S, **Biosensors Fundamentals and applications**, Oxford University Press, 1990.
4. Sadana.A, **Biosensors: Kinetics of Binding and Dissociation Using Fractals,** 1st edition, Elsevier B.V, 1995.

REFERENCE BOOKS

1. Charles T., Horngren, Geoge Foster and others**, "Cost Accounting A Managerial Emphasis"**, Prentice Hall of India, New Delhi.

2. Charles T., Horngren and George Foster**, "Advanced Management Accounting",** Seng Lee Press , Singapore, 2000.
3. Robert S., Kaplan Anthony, A. Alkinson, "**Management & Cost Accounting"**, Prentice Hall of India, New Delhi.
4. Ashish K. Bhattacharya," **Principles & Practices of Cost Accounting",** A. H. Wheeler publication.
5. N.D. Vohra, "**Quantitative Techniques in Management"**, Tata McGraw Hill Book Co. Ltd..

III SEMESTER M TECH BIOCHEMICAL ENGINEERING
SEMINAR - 18CHBCPCSR

Subject Code	18CHBCPCSR	L-T-P	0-0-2
No of Lecture Hrs/Week	00	Exam hours	3
Total No. of Lecture Hours	00	Credits	02
CIE	50 Marks	SEE	50 Marks

COURSE OUTCOMES
CO1: Communicate orally, present the technical research work using modern tools
CO2: Address certain societal issues and find out solutions from the studies
CO3: Present solution for the sustainable development

CIE EVALUATION
The student shall study minimum four recent research publications/patents published and present the same as seminar.
The topic of the presentation shall be related to M Tech specialization/project work
Three presentations shall be given by the student on the topic during the semester evaluated by the faculty in charge of the course.

SEE EVALUATION
The topic presented during the CIE evaluation shall be presented. The SEE evaluation at the end of the semester shall be done in the presence of external examiner.

III SEMESTER M TECH BIOCHEMICAL ENGINEERING
AUDIT COURSE- ENGLISH FOR RESEARCH PAPER WRITING - 18CHBCNCER

Subject Code	18CHBCNCER	L-T-P	2-0-0
No of Lecture Hrs/Week	00	Exam hours	00
Total No. of Lecture Hours	50	Credits	00
CIE	50 Marks	SEE	P/NP

COURSE OUTCOMES
CO1: Improve writing skills and level of readability
CO2: Excel the skills needed to write each section of a technical paper
CO3**:** Write conclusions through study and a good quality review paper

Unit 1

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction
Unit 2
Review of the Literature, Methods, Results, Discussion, Conclusions Key skills needed to write a Title, an Abstract, an Introduction, and for a Review of the Literature Skills needed to write the Methods, Results, Discussion, and the conclusions
REFERENCE BOOKS 1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books). 2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press. 3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.. Highman'sbook . 4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

III SEMESTER M TECH BIOCHEMICAL ENGINEERING

AUDIT COURSE- VALUE EDUCATION -18CHBCNCVE

Subject Code	18CHBCNCVE	L-T-P	2-0-0
No of Lecture Hrs/Week	00	Exam hours	00
Total No. of Lecture Hours	50	Credits	00
CIE	50 Marks	SEE	P/NP

COURSE OUTCOMES CO1; Acquire the knowledge of self-development CO2: Demonstrate the importance of human values CO3: Develop the overall personality
Unit 1
Values and self-development –Social values and individual attitudes; Work ethics, Indian vision of humanism; Moral and non- moral valuation. Standards and principles; Value judgements **Importance of cultivation of values**: Sense of duty, Devotion, Self-reliance. Confidence, Concentration; Truthfulness, Cleanliness; Honesty, Humanity. Power of faith, National Unity; Patriotism, Love for nature, Discipline Personality and Behavior Development - Soul and Scientific attitude; Positive Thinking. Integrity and discipline; Punctuality, Love and Kindness; Avoid fault Thinking; Free from anger, Dignity of labor
Unit 2

Personality and Behavior Development - Universal brotherhood and religious tolerance; True friendship; Happiness Vs suffering, love for truth; Aware of self-destructive habits; Association and Cooperation; Doing best for saving nature **Character and Competence** –Holy books vs Blind faith; Self-management and Good health; Science of reincarnation; Equality, Nonviolence ,Humility, Role of Women; All religions and same message; Mind your Mind, Self-control; Honesty, Studying effectively
REFERENCE BOOKS 1. Chakroborty, S.K. "**Values and Ethics for organizations Theory and practice**", Oxford University Press, New Delhi.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
PROJECT WORK -PHASE 2 - 18CHBCPWP2

Subject Code	18CHBCPWP2	Project Work Phase -2	0-0-12
No of Lecture Hrs/Week	---	Exam hours	3
Total No. of Lecture Hours	---	Credits	12
CIE	100 marks	SEE	100

COURSE OUTCOMES

CO1: Demonstrate research work as per the objectives set and suggestions by supervisors for the best outcomes of the work
CO2: Compute and analyze the experimental data
CO3: Publish the research work in a technical, and reputed journal

Project phase 2 is continuation of the Project phase 1.
The project work should be completed as per the comments/ inputs given by the examiners during the SEE of third semester.
The student shall publish the results of the research work as a technical paper in any one of the reputed journals.
The project work shall be evaluated as an external examination.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
INTERNSHIP - 18CHBCPCIN

Subject Code	18CHBCPCIN	L-T-P	0-0-8
No of Lecture Hrs/Week	---	Exam hours	03
Total No. of Lecture Hours	---	Credits	08
CIE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Understand the functioning of chemical process industry
CO2: Demonstrate the knowledge on the recent developments in the area
CO3: Iintegrate the theoretical knowledge with practical processes
CO4: Communicate skillfully and work in interdisciplinary teams in industry
CO5: Recognize the professional and ethical responsibility

The student shall undergo an internship in an industry/Research and Development center/National level reputed institutions for eight to ten weeks. The student shall make an internship report of the activities undertaken during internship to a panel comprising Internship Guide, a senior faculty from the department and Head of the Department.

The College shall facilitate and monitor the student internship program. The internship may be carried out during the semester vacation and continued during the semester**.** The student shall give a presentation on the Internship in the form of seminar. The internship report of each student shall be submitted to the Office of the Controller of Examinations/University. The seminar shall be evaluated by a panel comprising Internship Guide, a senior faculty from the department and Head of the Department for CIE.

The Internship work shall be evaluated as an external examination.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
FERMENTATION TECHNOLOGY - 18CHBCPEFT

Subject Code	18CHBCPEFT	L-T-P	2-0-0
No of Lecture Hrs/Week	02	Exam hours	3
Total No. of Lecture Hours	26	Credits	02
CIE Marks	50 marks	SEE	50 marks

COURSE OUTCOMES

CO1: Demonstrate the science underlying the conversion of raw materials, various source, their quality and their influence on the properties of final products

CO2: Design, formulate and select the skills to perform committed laboratory exercises through sterilization and other activities

CO3: Distinguish the design and operation of basic methods of fermentation process

CO4: Acquaint with the apparatus and instruments for technical procedures used in the laboratory

Unit 1	Hrs
Introduction To Fermentation Processes **Range of Fermentation Processes**: Microbial biomass, Enzymes, Metabolites and transformation processes; Development of fermentation Industry; Components of fermentation process **Microbial Growth Kinetics:** Batch culture; Continuous culture; Fed-batch culture; Applications	04
Unit 2	
Isolation, Preservation And Improvement of Industrial Microorganisms: Isolation methods utilizing the selection of desired characteristics; and not utilizing the selection of desired characteristics **Preservation Methods**: Low temperature, Dehydration, and their quality control; The selection and Isolation of induced mutants improving yields of secondary metabolites; Use of recombinant systems for the improvement of industrial microorganisms	07
Unit 3	
Media, Sterilization And Inococula: Medium formulation and Sources of Energy **Sterilization**: Medium Sterilization; Design of Batch and continuous sterilization **Inocula development for industrial fermentations:** Inocula for yeast, bacterial, fungal and mycelial processes; Aseptic inoculation of plant fermenters	07
Unit 4	
Instrumentation And Control: Control Systems: Manual, automatic and their	04

combination; Methods of measuring process variables; On-line analysis of other chemical factors; Application of computers in fermentation industry.	
Unit 5	
Effluent Treatment: Strength of fermentation effluents; Disposal Methods; Treatment processes: Aerobic and Anaerobic; Byproducts;	04

TEXT BOOK

1. Peter F. Stanbury, Alan Whitaker and Hope, **Principles of Fermentation Technology**, Pergamon Press, 2nd edition, Reprint 2010.

REFERENCE BOOKS

1. Shuler M. L. and Kargi F, **Bioprocess Engineering**, 2nd edition, Prentice Hall, 2002
2. Mitchell DA. Krieger N, Berovic, **Solid State Fermentation Bioreactors**, Springer press, Germany, 2005.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
ENZYME TECHNOLOGY- 18CHBCPEET

Subject Code	18CHBCPEET	L-T-P	2-0-0
No of Lecture Hrs/Week	02	Exam hours	03
Total No. of Lecture Hours	26	Credits	02
CEE	50 marks	SEE	50 marks

COURSE OUTCOMES

CO 1: Demonstrate the enzymes structure, properties, classification and their specificity
CO 2: Apply the knowledge to analyze the kinetics of reaction and arrive at a model representing the type of process
CO 3: Demonstrate the type of reaction through the analysis of the experimental data
CO 4: explain the industrial applications and analytical tools in use.

Unit 1	Hrs
Structures And Functions Of Proteins: Enzyme classification, based on structure classification of amino acids, classifications of proteins, specificities of enzyme action	04
Unit 2	
Kinetics: Chemical mechanisms of enzyme catalyzed reactions, introduction to bioenergetics and kinetics, kinetics of multi-substrate bio reactions	07
Unit 3	
Chemical Nature Of Enzyme Catalysis: Sigmoidal kinetics and allosteric enzymes, co-enzymes, significance of sigmoidal behavior	04
Unit 4	
Applications: Investigation of enzymes in biological preparation, extraction and purification, enzymes as analytical reagents	07
Unit 5	
Instrumental Techniques: Instrumental techniques available for using enzymatic analysis, applications in medicine, and industries	04

TEXT BOOK

1. Trevor Palmer, **"Understanding Enzymes", 4th** edition, Prentice Hall, 1991.

REFERENCE BOOKS

1. Bailey J.E and Ollis, D.F, "**Biochemical Engineering fundamentals"**, McGraw Hill, 2005.
2. John R. Whitaker, Alphons G. J. Voragen, and DWS Wong, **Handbook of Food**

Enzymology, Marcel Dekker, NewYork, 2003.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
AUDIT COURSE PEDAGOGY STUDIES - 18CHBCNCPS

Subject Code	18CHBCNCPS	L-T-P	2-0-0
No of Lecture Hrs/Week	00	Exam hours	00
Total No. of Lecture Hours	50	Credits	00
CIE	50 Marks	SEE	P/NP

COURSE OUTCOMES

CO1: Demonstrate the pedagogical practices used by teachers in formal and informal classrooms in developing countries

CO2: Understand the effectiveness of the pedagogical practices, with respect to type of conditions, and population of learners

CO3: Demonstrate the support by the teacher education (curriculum and practicum) and the school curriculum and guidance materials for the best and effective pedagogy

Unit 1

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology; Theories of learning, Curriculum, Teacher education; Conceptual framework, Research questions**:** Overview of methodology and Searching

Thematic Overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries; Curriculum, Teacher education

Evidence On The Effectiveness Of Pedagogical Practices: Methodology for the in depth stage: quality assessment of included studies; How can teacher education (curriculum and practicum) and the school; curriculum and guidance materials best support effective pedagogy; Theory of change

Unit 2

Strength and nature of the body of evidence for effective pedagogical practices: Pedagogic theory and pedagogical approaches; Teachers' attitudes and beliefs and Pedagogic strategies

Professional Development: alignment with classroom practices and follow-up Support; Peer support; Support from the head teacher and the community; Curriculum and assessment; Barriers to learning: limited resources and large class sizes

Research Gaps And Future Directions: Research Design; Contexts; Pedagogy; Teacher Education; Curriculum And Assessment ; Dissemination And Research Impact

REFERENCE BOOKS AND CITATION

1. Ackers J, Hardman F, "**Classroom interaction in Kenyan primary schools, Compare**", 31 (2): 245-261, 2001.

2. Agrawal M , " **Curricular reform in schools: The importance of evaluation**", Journal of Curriculum Studies, 36 (3): 361-379, 2004.

3. Akyeampong K, Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID, 2003.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J , Improving teaching and learning of

basic mathematics and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282, 2013.
5. Alexander R.J., "**Culture and pedagogy: International comparisons in primary education",** Oxford and Boston: Blackwell, 2001.
6. Chavan M , "**Read India: A mass scale, rapid, 'learning to read' campaign",** 2003.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
AUDIT COURSE STRESS MANAGEMENT BY YOGA-18CHBCNCSY

Subject Code	18CHBCNCSY	L-T-P	2-0-0
No of Lecture Hrs/Week	00	Exam hours	00
Total No. of Lecture Hours	50	Credits	00
CIE	50 Marks	SEE	P/NP

COURSE OUTCOMES

CO1: Develop healthy mind in a healthy body thus improving social health also
CO2: Improve efficiency by overcoming stress
CO3: Demonstrate the uses orally and exercises physically

Unit 1

Astanga: Definitions of eight parts of yoga
Yam and Niyam
Do`s and Don't's in life:
i) Ahinsa, Satya, Astheya, Bramhacharya And Aparigraha
ii) Shaucha, Santosh, Tapa, Swadhyay, Ishwarpranidhan

Unit 2

Asan: Various yoga poses and their benefits for mind & body
Types of pranayam

REFERENCE BOOKS

1. Janardan Swami Yogabhyasi Mandal, " **Yogic Asanas for Group Tarining-Part-I**" , Nagpur.
2. Swami Vivekananda, "**Rajayoga or conquering the Internal Nature**", Advaita Ashrama (Publication Department), Kolkata.

IV SEMESTER M TECH BIOCHEMICAL ENGINEERING
AUDIT COURSE DISASTER MANAGEMENT - 18CHBCNCDM

Subject Code	18CHBCNCDM	L-T-P	2-0-0
No of Lecture Hrs/Week	00	Exam hours	00
Total No. of Lecture Hours	50	Credits	00
CIE	50 Marks	SEE	P/NP

BMS COLLEGE OF ENGINEERING, BENGALURU – 19

(Autonomous Institute, Affiliated to VTU)

COURSE OUTCOMES

CO1: Demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO2: Evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO3: Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO4: Demonstrate the strengths and weaknesses of disaster management approaches, planning and programming

Unit 1

Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster

Natural and Manmade disasters: Difference, Nature, Types and Magnitude

Repercussions of Disasters and Hazards: Economic damage, Loss of human and animal life, Destruction of ecosystem Man-made disasters: Nuclear Reactor; Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of disease and Epidemics, War and Conflicts

Unit 2

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides And Avalanches

Disaster Preparedness And Management: Preparedness: Monitoring of phenomena Triggering a disaster or hazard

Evaluation of Risk: Application of remote sensing, Data from meteorological and other agencies, Media reports: Governmental and community preparedness

REFERENCE BOOKS

1. R. Nishith, Singh AK, "**Disaster Management in India: Perspectives, issues and strategies** "'New Royal book Company.

2. Sahni, Pardeep Et. Al. (Eds.)," **Disaster Mitigation Experiences And Reflections**", Prentice Hall Of India, New Delhi.

3. Goel S. L. , "**Disaster Administration And Management Text And Case Studies**" ,Deep & Deep, Publication Pvt. Ltd., New Delhi.